Appendix A

Profile of Major Facilities and Remedial Action Programs

The Department of Energy's budget for the Office of Environmental Restoration and Waste Management supports a number of facilities and activities across the nation. This appendix briefly describes the budgets and environmental challenges for the department's major facilities and remedial action programs. Table A-1 presents their 1994 appropriations and 1995 budget requests; Table A-2 shows the growth in their budgets since 1990.[1]

Hanford Site

The Hanford Site occupies 560 square miles in southeastern Washington State, near Richland. One of the original facilities of the Manhattan Project, it was established in 1943 as the site of the first full-size reactor to produce plutonium. The historic B-reactor produced the plutonium used in "Fat Man," the nuclear bomb dropped on Nagasaki in August 1945. After World War II, Hanford continued to produce and process plutonium for nuclear weapons.

The activities at Hanford's nuclear reactors and chemical separation facilities have generated large quantities of dangerous wastes--radioactive materials, heavy metals, volatile organic compounds, and other hazardous chemicals. Over the years, wastes have been disposed of in large underground storage tanks. The oldest tanks, with only single shells, are of greatest concern because many are leaking or feared to be leaking. The reactors also present disposal problems because of their radioactivity.

Hanford's environmental cleanup budget for 1994 is nearly $1.5 billion, 24.1 percent of DOE's cleanup budget. DOE anticipates that Hanford will require approximately that share of the cleanup budget for the foreseeable future.

Savannah River Site

The Savannah River Site is located on approximately 325 square miles of land along the Savannah River in south-central South Carolina near Aiken. DOE considers it one of the department's greatest environmental challenges. Its five reactors, two chemical separation facilities, and reactor fuel manufacturing facility have produced tritium and plutonium. As a consequence of these activities, it has various kinds of radioactive and mixed wastes to dispose of. Savannah River's Defense Waste Processing Facility is intended to stabilize high-level radioactive waste.

Savannah River's environmental cleanup budget for 1994, $757.4 million (12.3 percent of the total), is about 3 percent lower than its peak of $779.0 million in 1993.

1. The budget totals for 1994 and 1995 differ from those given in Chapter 2 because they include the budget of the Uranium Enrichment Decontamination and Decommissioning program.

Oak Ridge Reservation

The Oak Ridge Reservation, located near Oak Ridge, Tennessee, contains several discrete facilities that together account for 10.6 percent of DOE's cleanup budget in 1994.

The K-25 site was one of the original Manhattan Project facilities, with a mission to enrich uranium by gaseous diffusion. Following shutdown of the uranium enrichment process in 1987, the K-25 site has been used for various environmental cleanup functions. Its cleanup budget in 1994 is $270.2 million.

Table A-1.
Environmental Cleanup Budgets for DOE's Facilities and Remedial Action Programs, 1994 and 1995

Facility or Program	1994 Appropriation: In Millions of Dollars	1994 Appropriation: As a Percentage of DOE's Cleanup Budget	1995 Budget Request (Millions of dollars)
Headquarters			
Washington, D.C.	726.7	11.8	995.0
Facilities			
Hanford	1,490.0	24.1	1,591.6
Savannah River	757.4	12.3	743.6
Oak Ridge	652.7	10.6	648.3
Rocky Flats	477.2	7.7	639.7
Idaho National Engineering Laboratory	408.7	6.6	392.4
Fernald	304.4	4.9	294.2
Waste Isolation Pilot Plant	185.3	3.0	184.6
Los Alamos National Laboratory	185.1	3.0	180.0
Lawrence Livermore National Laboratory	89.5	1.4	80.2
Sandia National Laboratory (Albuquerque)	73.0	1.2	51.9
Mound Plant	47.4	0.8	45.0
Pantex Plant	35.7	0.6	45.6
Nevada Test Site	18.0	0.3	23.1
Kansas City Plant	14.1	0.2	13.2
Pinellas Plant	11.1	0.2	9.0
Other	551.7	8.9	167.9
Remedial Action Programs			
Formerly Utilized Sites Remedial Action Program	42.7	0.7	74.1
Uranium Mill Tailings Remedial Action Project	104.1	1.7	100.9
Total[a]			
All Facilities and Programs	6,174.8	100.0	6,280.3

SOURCE: Congressional Budget Office based on data from Department of Energy, *Environmental Management 1994*, DOE/EM-0119 (February 1994).

a. Includes funds for the Uranium Enrichment Decontamination and Decommissioning program.

Table A-2.
Funding by Facility, 1990-1995 (In millions of dollars)

	Appropriations					1995
	1990	1991	1992	1993	1994[a]	Request[a,b]
Headquarters						
Washington, D.C.	60.5	196.3	416.5	447.2	726.7	995.0
Facilities						
Hanford	441.3	828.6	1,060.4	1,481.4	1,490.0	1,591.6
Savannah River	471.1	644.6	550.5	779.0	757.4	743.6
Oak Ridge	282.7	353.3	448.6	553.1	652.7	648.3
Rocky Flats	139.7	173.0	181.8	291.2	477.2	639.7
Idaho National Engineering Laboratory	185.6	323.2	248.4	372.9	408.7	392.4
Fernald	84.4	263.6	214.3	293.9	304.4	294.2
Waste Isolation Pilot Plant	104.6	164.0	141.0	150.7	185.3	184.6
Los Alamos National Laboratory	47.9	82.1	120.5	172.9	185.1	180.0
Lawrence Livermore National Laboratory	33.8	52.7	77.8	107.6	89.5	80.2
Sandia National Laboratory (Albuquerque)	16.3	37.7	58.5	73.7	73.0	51.9
Mound Plant	19.1	30.7	42.2	44.5	47.4	45.0
Pantex Plant	5.4	19.7	26.2	41.0	35.7	45.6
Nevada Test Site	13.0	n.a.	13.7	20.7	18.0	23.1
Kansas City Plant	12.0	17.4	27.5	16.9	14.1	13.2
Pinellas Plant	3.0	4.7	4.6	9.2	11.1	9.0
Other	353.7	260.6	463.5	484.2	551.7	167.9
Remedial Action Programs						
Formerly Utilized Sites Remedial Action Program	0	29.2	49.0	40.9	42.7	74.1
Uranium Mill Tailings Remedial Action Project	n.a.	119.6	141.9	139.3	104.1	100.9
Total						
All Facilities and Programs	2,274.1	3,601.0	4,286.9	5,520.3	6,174.8	6,280.3

SOURCE: Congressional Budget Office based on data from Department of Energy, *Environmental Management 1994*, DOE/EM-0119 (February 1994).

NOTE: n.a. = not available.

a. The 1994 and 1995 budgets include funding for the Uranium Enrichment Decontamination and Decommissioning program.

b. The 1995 budget request allocates all funding for technology development ($426.4 million) and transportation management ($20.7 million) to headquarters.

The Y-12 plant also was built during World War II. Its original mission was to separate uranium isotopes by an electromagnetic process. After the war, it was used for manufacturing and developmental engineering and for treatment, storage, and disposal of radioactive and hazardous wastes. Its environmental budget for 1994 is $97.8 million, a decline of about $10 million from 1993.

The Oak Ridge National Laboratory conducts research on fusion, fission, and many other energy technologies. Its site is contaminated with radioactive and hazardous wastes. The budget for environmental cleanup in 1994 is $163.1 million, a decline of $17 million from 1993.

A new responsibility of the Oak Ridge office in 1994 is the Uranium Enrichment Decontamination and Decommissioning program. This program, which is funded through taxes paid by utilities to support enrichment of uranium used at nuclear power plants, is not part of the weapons-related work described in the main body of this study. But its budget of $286.3 million in 1994 accounts for a large share of the budgetary growth at Oak Ridge ($199.1 million) and at the gaseous diffusion plants at Portsmouth ($47.8 million) and Paducah ($39.4 million).

Rocky Flats

The Rocky Flats Plant is located about 16 miles northwest of Denver, Colorado. The plant itself covers about 400 acres on an 11-square-mile site. From 1952 to 1992, Rocky Flats produced weapons components fabricated from plutonium and other metals. As Denver has grown, suburban development has pushed closer to Rocky Flats, and concerns about migration of contaminated groundwater as well as other environmental risks have increased.

The environmental cleanup budget for Rocky Flats in 1994 is $477.2 million, 7.7 percent of the total. The growth of its budget by $186 million (a rate of 63.9 percent) from 1993 to 1994 made it the fastest-growing part of the Environmental Restoration and Waste Management program.

Idaho National Engineering Laboratory

The Idaho National Engineering Laboratory (INEL) covers about 890 square miles in southern Idaho, about 40 miles northwest of Idaho Falls. Its research, development, and operations activities have generated radioactive, hazardous, and mixed wastes. The Idaho Chemical Processing Plant (ICPP), located at the same site, handles and stores spent fuel from naval reactors. It treats wastes to stabilize them and reduce their volume.

The environmental cleanup budget for INEL (including ICPP) in 1994 is $408.7 million, 6.6 percent of the total.

Fernald

The Fernald Environmental Management Project is located on 1,050 acres near Fernald, Ohio, about 17 miles northwest of Cincinnati. Formerly a producer of uranium metal ingots and uranium oxides, it became in 1991 the first DOE facility to be turned over entirely from production to environmental restoration. One of the major problems is groundwater contaminated by radionuclides, metals, inorganic compounds, and volatile organic compounds.

Fernald's environmental restoration budget for 1994 is $304.4 million, 4.9 percent of the total.

Waste Isolation Pilot Plant

The Waste Isolation Pilot Plant (WIPP), located about 25 miles east of Carlsbad, New Mexico, is intended to be the long-term disposal site for transuranic wastes from Hanford, Savannah River, INEL, Rocky Flats, and other DOE facilities. Development of the facility has been held up by regulatory hurdles. One major obstacle was overcome with passage in 1992 of the WIPP Land Withdrawal Act, which withdrew from public use lands surrounding WIPP, allowing DOE to proceed with testing once it obtains approval from regulators. DOE still faces the challenge of convincing regulators and the general public that it will ensure safe storage of wastes. WIPP's 1994 budget of $185.3 million is about 3 percent of DOE's cleanup total.

Los Alamos National Laboratory

The Los Alamos National Laboratory, located about 25 miles north of Santa Fe, New Mexico, is the site of nuclear weapons research and development dating back to World War II. Its activities have resulted in a variety of hazardous and radioactive wastes. Its environmental budget of $185.1 million in 1994 is about 3 percent of the total.

Lawrence Livermore National Laboratory

The Lawrence Livermore National Laboratory is in Livermore, California, 40 miles southeast of San Francisco. It has interim status under the Resource Conservation and Recovery Act for treatment, storage, and disposal of hazardous, mixed, and low-level radioactive waste. It also has nonnuclear explosive test facilities at a site about 15 miles southeast of the main site. Testing activities have resulted in contamination of both soil and groundwater. The 1994 environmental cleanup budget is $89.5 million, about 1.4 percent of the total.

Sandia National Laboratory

The Sandia National Laboratory performs research, development, and testing of nonnuclear components of nuclear weapons at sites near Albuquerque, New Mexico, and Livermore, California. This work has resulted in hazardous, radioactive, and mixed wastes. The environmental cleanup budgets are $73.0 million at Albuquerque and $5.7 million at Livermore in 1994. Together they account for 1.3 percent of the total.

Mound Plant

The Mound Plant in Miamisburg, Ohio, conducted research and development and produced nonnuclear and tritium-containing components for nuclear weapons. In 1993, its mission changed from production to environmental cleanup. Its environmental budget of $47.4 million is a little less than 1 percent of the total.

Pantex Plant

Nuclear weapons are assembled and disassembled at the Pantex Plant, near Amarillo, Texas. The environmental cleanup budget is $35.7 million, about 0.6 percent of the total cleanup budget.

Nevada Test Site

The Nevada Test Site covers about 1,350 square miles in Nevada, about 65 miles northwest of Las Vegas. Above-ground and underground tests of nuclear weapons have contaminated both surface and subsurface soils. In addition, transuranic waste and mixed waste are stored at the site. The cleanup budget for 1994 stands at $18 million.

Kansas City and Pinellas Plants

The Kansas City Plant manufactures nonnuclear weapons components. These operations result in hazardous and toxic wastes. The environmental cleanup budget in 1994 is $14.1 million.

The Pinellas Plant, near St. Petersburg, Florida, developed and produced special electronic and mechanical equipment. Production has ceased, having been consolidated at the Kansas City Plant. The environmental cleanup budget is about $11.1 million in 1994.

Remedial Action Programs

In addition to its facilities, DOE has two major programs for cleaning up contaminated sites.

The Formerly Utilized Sites Remedial Action Program is intended to clean up radioactive contamination at 33 sites in 13 states resulting from early activities of the atomic energy program. Its 1994 budget is about \$42.7 million. The program is overseen by the Oak Ridge field office.

The Uranium Mill Tailings Remedial Action Project is intended to stabilize and control mill tailings at 24 sites and approximately 5,000 properties in 10 states and on two Indian tribal lands. Cleanup of surface contamination is nearly complete, but cleanup of groundwater is still at an early stage of assessment. Its 1994 budget of \$104.1 million is overseen by the Albuquerque field office.

Appendix B

Estimating the Costs of Cleaning Up DOE Sites

Estimators of costs at the site or project level face many of the same problems as those working at the program level. Information yet to be acquired about the type, magnitude, location, and toxicity of contaminants and the likelihood of their migrating to populated areas will affect the estimates of remediation costs. But one advantage at the site level is that the project typically is well defined, as are the tasks required to accomplish it. Cost engineers break down the work needed to accomplish each task into its basic components, known as the work breakdown structure (WBS). The Department of Energy typically aggregates several tasks within a WBS into an activity data sheet (ADS), the basic building block of the department's five-year plan. The ADSs set forth the specific assessment or cleanup tasks that serve as the basis for cost estimates.

Estimating the costs of assessing and cleaning up a site typically begins by identifying all the basic components of work, such as drilling wells or digging up soil. Cost estimators determine the amount of labor of different types and the equipment and materials needed to complete the task. After multiplying the inputs by wage rates and other unit costs, estimators add in overhead and other allowances they deem necessary to arrive at a cost estimate. The job of estimating the costs of completing individual cleanup tasks throughout the nuclear complex typically falls on contractors at DOE's facilities, in consultation and coordination with DOE staff at the facilities. But headquarters staff also become involved, providing general guidance on preparing cost estimates and monitoring and coordinating the work done at the field offices.

Cost estimators use a variety of analytical tools. The choice of tools and the degree of confidence in the estimate depend on the stage and type of activity. DOE's environmental restoration work consists of two principal types of activities: assessment and remediation (cleanup). The costs of each are estimated separately.

Estimating the Costs of Assessing Sites

Assessing a site to determine the type and extent of contamination is perhaps the more challenging activity to estimate because so many factors are unknown. In this respect, assessment is akin to research and development: at the start of a project, researchers do not know exactly what they will encounter and therefore cannot confidently predict costs, schedules, or outcomes. For example, before beginning assessment, workers may not know how many monitoring wells will be needed to obtain an accurate picture of subsurface contamination.

DOE makes three types of estimates of assessment costs: planning estimates, preliminary estimates, and detailed estimates.[1] Planning estimates are made during the preliminary assessment/site investigation (PA/SI) stage of a cleanup project. At this stage, cost estimates are based on what little information is available about a site, such as location and history of use. DOE uses analogy, simple cost-estimating relationships, and statistical tools to

1. Department of Energy, Environmental Restoration and Waste Management Cost Assessment Team, *Cost Estimating Handbook for Environmental Restoration* (n.d.; updated periodically), p. 2-2.

make cost estimates.[2] Because of uncertainties, contingency factors must be built in to the cost estimates.

After the PA/SI is completed, DOE makes a preliminary estimate of costs as it develops a work plan for the remedial investigation/feasibility study (RI/FS). By this time, cost estimators have some idea about the kinds of assessment activities to be carried out--for example, drilling, sampling, laboratory analysis--and can make rough estimates based on past unit costs of such activities.

During the RI/FS stage, DOE makes detailed estimates of assessment costs as additional information becomes available. "Detailed" estimates can be based on engineering data and drawings, specifications, the contract schedule, and other factors specific to each project. By this point, cost estimates can be made with much greater confidence than before. From experience, cost estimators know roughly how much labor--and what skill levels--will be required to complete certain tasks. Applying hourly rates gives an estimate of labor costs. Similarly, they can estimate the amount of equipment and materials. The estimators add an overhead rate to take into account management resources devoted to the task. But none of these tasks is strictly mechanical. All require judgment and "guesstimates" about the amount of resources needed: the less well defined a task, the more subjective the cost estimates.

Estimating the Costs of Cleaning Up Sites

For long-range planning and budgeting purposes, DOE makes preliminary estimates of cleanup costs even before assessment has proceeded far enough to reduce uncertainty about what the eventual cleanup process will entail. These "planning estimates" are like those for assessment in that they come so early in the process that there is little solid information on which to base them and therefore considerable uncertainty in the estimate.

2. Ibid.

As part of the RI/FS stage, the Comprehensive Environmental Response, Compensation, and Liability Act (which established Superfund) requires analysis of alternative remedies and their costs. The "feasibility estimates" of cost, schedule, and design that are prepared at this stage serve as a basis for selecting a remedy in the record of decision. In principle, DOE considers the estimates of cost and schedule made at this point as forming the first formal baseline for measuring and evaluating cleanup performance.[3] In practice, however, very few projects at major DOE facilities have reached the record-of-decision stage.[4]

As DOE progresses with cleanup, cost estimates can become more detailed, following the same pattern as estimates of assessment costs.

Tools for Estimating Costs

Estimating costs of environmental cleanup, if not still in its infancy, can hardly be called a mature science. The Superfund program is just 13 years old, and given the time required to identify and assess contaminated sites before proceeding to remedial action, the amount of cleanup experience on which to base estimates of new projects is limited. As cleanup efforts proceed around the nation--not only at DOE facilities but also at defense and other federal facilities and at private Superfund sites--professional cost estimators gain new information to add to their data bases that they can then use in estimating costs of new projects. The lessons learned from these experiences are shared through interagency task forces as well as professional journals and conferences.

DOE's Environmental Restoration and Waste Management Cost Assessment Team has prepared the *Cost Estimating Handbook for Environmental Restoration* to assist the DOE offices that estimate the cleanup costs at various sites. The handbook

3. Ibid., p. 2-5.

4. The DOE cleanup program that is farthest along is the Uranium Mill Tailings Remedial Action Project. The nature of cleanup work at these sites is so different from cleanup at the major weapons facilities, however, that it provides only limited guidance to cost estimators.

describes different types of cost estimates and provides guidance on how to develop them. It makes suggestions on how to deal with uncertainties, contingencies, cost escalation, and other factors, and it describes data bases, tools, and techniques that can be useful to cost estimators in the field offices.

Building the cost estimates from the bottom up--estimating the cost of each component of work required to complete a task--is just one approach to the problem of estimating the environmental cleanup costs facing DOE. Another approach is to develop parametric cost-estimating models that express cleanup costs as a function of such variables as the type, volume, and concentration of contaminants; the medium (soil, groundwater, air); and the required remedy. Both DOE and the Environmental Protection Agency have developed such models to help estimate Superfund and similar cleanup costs.

DOE's Models for Estimating Costs

Cost analysts from the firm Independent Project Analysis, Inc. (IPA), have prepared studies on estimating costs and schedules of assessment and cleanup projects for the Department of Energy.[5] These studies contribute to the understanding of assessment and cleanup costs by developing statistical relationships between costs and a number of variables and between growth in costs and a number of variables. They have found that about three-quarters of the variance in assessment costs can be explained by an equation with five independent variables: the number of borings and new wells, an index of site complexity, the threat posed to the surrounding community, the number of previous cleanup efforts at a site, and whether assessment tasks at a site are occurring in sequential phases or concurrently.[6] Growth in costs can largely be explained by variables describing the complexity of the site, the complexity of the media, and the stage of the project relative to other work at the site (referred to as project definition).[7]

IPA has developed similar models for the remediation of hazardous waste sites. It finds that cleanup costs can be expressed as a function of six key variables: the volume of waste excavated, technological complexity, whether the site is a landfill, whether there is mixed debris at the site, the complexity of the waste, and whether the primary threat is groundwater contamination.[8] Together, these variables explain 96 percent of the variance in cleanup costs. Sources of error in cost estimates are the lack of complete information about the project, the type and complexity of remedial technologies, the complexity of the media, and the complexity of wastes at the site.[9]

IPA's studies drew from experiences at a variety of hazardous waste sites--not only DOE sites but also EPA Superfund and private industrial sites. But since the DOE cleanup program is still relatively young, there is not much experience with sites containing radioactive wastes. As more DOE sites are assessed and cleaned up, IPA plans to enter them into its data base and reestimate the relationships between costs and other factors.

EPA's CORA Model

The EPA uses the Cost of Remedial Action (CORA) model to estimate the costs of cleanup at individual Superfund sites.[10] EPA also aggregates the estimates generated by the CORA model in developing the overall budget for its Superfund program. To use the CORA model, one enters data on site characteristics, the kinds and amounts of contaminants, the cleanup technologies, and other perti-

5. Brett R. Schroeder and others, *The HAZRISK Assessment Study*, prepared for the Department of Energy by Independent Project Analysis, Inc., WD-90-04-HAZ (December 21, 1990); and B. R. Schroeder and J.B. Hartung, *The HAZRISK Cleanup Report*, prepared for the Department of Energy by Independent Project Analysis, Inc. (Draft, February 1991).

6. Schroeder and others, *The HAZRISK Assessment Study*, p. 23.

7. Ibid., pp. 38-39.

8. Schroeder and Hartung, *The HAZRISK Cleanup Report*, pp. 24-25.

9. Ibid., pp. 45-46.

10. Environmental Protection Agency, Office of Solid Waste and Emergency Response, *The Cost of Remedial Action Model, Quick Reference Fact Sheet*, Publication No. 9375.5-06a/FS (May 1991). In addition to estimating costs, CORA contains a module that suggests the kind of remedial action that should be taken at each site.

nent information; the model uses this information to estimate cleanup costs. Tests of the model suggest that actual costs run from 30 percent below to 50 percent above the cost estimate it generates. Although the CORA model deals with most types of hazardous contaminants, it does not estimate cleanup costs at mining sites or sites with radioactive waste, nor is it able to estimate costs associated with such emerging technologies as in situ vitrification. It could be expanded, however, to cover additional technologies or types of pollution.

Appendix C

Description of Specific Integrated Demonstrations and Estimates of Savings

Preliminary results from the Department of Energy's research efforts have identified two areas in which the department feels technology can yield an early payoff--groundwater and soils cleanup, and waste retrieval and processing. DOE is conducting several integrated demonstrations in these two areas; they represent the two biggest items in the portion of the budget for technology development that funds research and development (see Chapter 4). Furthermore, one of DOE's major technical challenges involves cleaning up contaminants in the soil or groundwater.

Cleaning Up Soils

New technologies could save significant sums of money by reducing the amount of contaminated soil requiring disposal. Conventional treatment of contaminated soil involves excavating all soil that might contain waste, treating it if appropriate, and then disposing of it at an approved site. Without the ability to precisely locate contaminants within the soil, current techniques using bulldozers often require excavating at least twice the estimated volume of contaminated soil in order to ensure that all contamination has been removed. DOE estimates that excavating and disposing of soil from the Nevada Test Site alone could cost $2.5 billion using current techniques.

DOE is investigating techniques that would reduce the amount of soil that must be excavated initially as well as methods of treating the contaminated soil to reduce the volume of waste ultimately requiring disposal. By monitoring soil as it is excavated using a special "rotomill" machine, DOE can remove less material requiring subsequent treatment. The department is also attempting to further concentrate plutonium in the soil using such techniques as magnetic separation and centrifugation. According to DOE estimates, rotomilling and then concentrating the plutonium could reduce the amount of soil to be disposed of by a factor of five; the savings at the Nevada Test Site would be $2 billion, or 80 percent of the cost of using current technology.

Cleaning Up Groundwater

Cleaning contaminated groundwater is another thorny and major problem facing DOE. First, groundwater contamination has been detected at almost all of the major installations in DOE's nuclear weapons complex, although the extent and types of contamination at individual sites have not yet been fully characterized. Second, cleaning up contaminated groundwater may be very difficult, expensive, and time consuming. The most common technique used for eliminating contaminants from groundwater is to extract the water from the aquifer and then treat it. This pump-and-treat process can take a very long time because contaminants can diffuse or be absorbed into the material in the aquifer and be slowly released back into the water as it is being treated. For all of these reasons, cleaning up the contaminated groundwater at DOE sites using current techniques could be a very difficult and costly, if not impossible, task.

To reduce the time and money needed to remediate the groundwater at its installations, DOE is looking at new methods for extracting contaminants from groundwater that are more efficient than simply pumping groundwater up to the surface to treat it. Again, DOE has identified significant potential savings in terms of cost, time (from years to months), or both, using various techniques under investigation. The department estimates that these new methods could save about $3 billion over the cleanup period.

One method, called air stripping, pumps compressed air down into the aquifer containing the groundwater to flush out some of the contaminants, which are then collected in a vacuum grid located above the water table. This method works particularly well for extracting volatile organic compounds from groundwater. The vaporized contaminants are then pumped from the vacuum grid up to the surface where they can be treated. DOE estimates that air stripping can reduce the cost of cleaning up groundwater contaminated with volatile organic compounds by 65 percent compared with conventional pump-and-treat methods. DOE is conducting an integrated demonstration at Savannah River using air stripping and feels that such a technique might be applicable to half of its sites and of those sites belonging to the Department of Defense (DoD) that have groundwater contaminated with volatile organic compounds.

As part of that demonstration, DOE is also investigating technologies that would destroy contaminants while still in the aquifer. Such methods, called in situ remediation, would obviate the need for any above-ground treatment of vapors or water. Techniques such as air stripping, by pumping gas into the aquifer, would also allow the introduction of beneficial microbes for bioremediation or chemicals to break down contaminants in the groundwater. DOE estimates that such techniques could reduce costs by 70 percent compared with conventional pump-and-treat methods and that bioremediation might be applicable to 15 percent of DOE and DoD sites with contaminated groundwater.

Waste Retrieval and Processing

The Department of Energy has large amounts of waste in various types of storage--more than 1 million 55-gallon drums, some of which are buried, and more than 300 underground tanks. Many of these drums and tanks are decades old and are, or could be, leaking. A major task facing DOE involves locating the waste and retrieving, characterizing, and disposing of it in a safe and stable manner. DOE is investigating several techniques to address these problems, including ways to identify and separate contaminated soil from clean soil and to stabilize extremely radioactive waste stored in underground tanks and provide for its ultimate disposal. Integrated demonstrations are being conducted at the Idaho National Engineering Laboratory on buried waste, and at five sites including Hanford on underground storage tanks.

Buried Waste

The integrated demonstration at the Idaho National Engineering Laboratory is exploring and developing ways to locate buried radioactive waste more precisely and to retrieve the contaminated soil and separate it from clean soil. By knowing where the waste is buried, the amount of soil to be excavated can be reduced by 20 percent, according to DOE estimates. New and better ways to retrieve the soil could eliminate the need for workers to wear protective clothing, which limits their work time to two or three hours per day. Improved methods would also increase efficiency by a factor of at least two. The cost of cleaning up waste buried in trenches using current technology ranges from $14,000 to $26,000 per cubic meter. New characterization and retrieval processes could reduce costs to an estimated $700 per cubic meter. DOE estimates that at least 59,000 cubic meters of transuranic waste and surrounding soil need to be cleaned up at the Idaho site. If the cost to retrieve and dispose of a cubic meter of buried waste can be reduced to the levels estimated by DOE, then savings at that site alone could reach $1.5 billion.

Underground Storage Tanks

The Department of Energy has more than 332 underground tanks at five installations that store waste in various forms with varying levels of radioactivity. Some tanks are now 50 years old; because they were intended originally only as temporary storage facilities, some have degraded over time and some of their contents have leaked into the surrounding soil.

DOE has chosen Hanford as one of the installations at which to investigate and demonstrate new technologies for dealing with the problem of underground storage tanks. Hanford alone has more than 170 underground storage tanks, 149 of which are of the obsolete, single-shell design most prone to leaks. The first task is to determine exactly what is in the tanks, since some were filled more than 40 years ago and no one knows precisely what chemicals they contain. Most of the material remaining in the tanks is a highly radioactive sludge or cake that is relatively hard and would require drilling by special tools to attain cores for sampling. Such a procedure, within the tank, would be difficult and costly. DOE estimates that it needs five samples from each tank to determine the contents using current techniques. DOE also predicts that two fewer samples would be needed using newer techniques such as laser range-finders deployed inside the tank on a remotely operated robotic arm to identify the best locations for taking samples. At $1 million per sample, reducing the number of samples needed by 40 percent could result in a savings of $300 million at Hanford alone, according to DOE.

Appendix D

The Acquisition Process for a Major Weapon System

Chapter 4 included a discussion of ways in which the Department of Energy's management of its projects to develop new technologies might be improved. One possibility would involve establishing a framework for periodic review and decision points during a project. The process used to monitor Department of Defense (DoD) programs was presented as a possible model for such a framework. This appendix provides a brief description of that process.

The Department of Defense has established a process to manage the development and production of major weapon systems. This process is laid out in Department of Defense Instruction 5000.2, which has been revised many times in the past 20 years. Nevertheless, the basic concept remains the same--to provide a basis for comprehensive management and decisionmaking associated with shepherding a weapon from its inception until it rolls off a production line.

The design and development of major systems such as aircraft, missiles, and ships is a long process, in many cases taking 12 to 15 years. A weapon system proceeds through a series of development stages, from identifying alternative concepts for the system to initial operational capability, deployment, and support. These stages are paralleled by a series of technical and management decisions, called milestones, made by the Under Secretary of Defense for Acquisition, the head of the relevant service (for example, the Secretary of the Air Force), or the service's delegated acquisition executive.

First, the military services, the Office of the Secretary of Defense, or the Joint Chiefs of Staff determine that a particular mission requires a new weapon system to add operational capabilities or improvements that will enhance the effectiveness of existing equipment. The originator prepares a mission need statement (MNS) that is then reviewed by the appropriate DoD component. Milestone 0 is the decision point at which the Defense Acquisition Board (DAB) validates the need for a new weapon to meet the threat and grants permission to proceed to the next phase.

Following favorable review at Milestone 0, the new weapon system proceeds into the concept exploration and definition phase. During this relatively short period--typically one to two years--activity focuses on selecting the best alternative to fulfill the mission needs stated in the MNS. At the next milestone, Milestone I, the service seeks approval to initiate a new program and enter the demonstration and validation phase. The DAB establishes baselines for cost, schedule, and performance characteristics to be met at the next milestone.

During the demonstration and validation phase, the program office responsible for the weapon system directs preliminary engineering and design work--typically performed by a defense contractor--with an emphasis on reducing the risk of incorporating new and emerging technologies into the final weapon system. The contractor may develop early prototypes to demonstrate the feasibility of systems, subsystems, and components. Also during this phase, which usually lasts two to three years but can extend for five or more years in the case of complicated systems, the contractor may conduct some preliminary tests to demonstrate that the system is ready to enter the next phase.

Milestone II marks the entry into engineering and manufacturing development. At this decision point, the review board must be convinced that the production of the weapon system, and its performance up to standards, are feasible. The program's cost, schedule, and performance characteristics, initially established at Milestone I, are updated. The new thresholds serve as development baselines for reports to the Congress. The DAB also reviews and updates the plans for testing, acquisition, and support and logistics.

Following favorable review at Milestone II, the weapon system enters the engineering and manufacturing development phase in which the final design for the system is established. Tests are conducted to determine that design and performance criteria are met and that the weapon system will perform as desired in an operational setting. Any final design and engineering changes needed to ready the system for production are made.

Milestone III marks approval for production. At this final major decision point, the review board examines results of tests conducted during the previous phase and establishes the acquisition strategy and production baseline. Before the system may enter full-rate production, the Secretary of Defense must certify to the Congress that all operational testing has been completed successfully. The review board may approve initial production (at Milestone IIIA) before testing has been completed, with a proviso for subsequent review and approval for full-rate production at Milestone IIIB following the completion of all tests.

Once the system has been produced and deployed to the field, management responsibility for the system is transferred to the service and the relevant subordinate command. The military personnel who use and maintain the weapon continue to monitor its performance so that problems can be identified and fixed. Some weapons, after being deployed for a number of years, require major modifications to address a different mission, correct an operational deficiency, or incorporate new technology. If the modification is sufficiently expensive, its execution may generate another milestone (IV) and be subject to reporting requirements similar to those associated with new weapons.

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